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	Patents ADP number *(if you know it)*	7751795001		
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4.	Title of the invention	REFRIGERANT		
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REFRIGERANT

This invention relates to a refrigerant particularly but not exclusively for air conditioning systems. The system relates especially to refrigerant compositions which have no adverse effect on the atmospheric ozone layer and to compositions which can be added to existing refrigerants which are compatible with lubricants commonly used in refrigeration and air conditioning systems. The invention also relates to a method of modifying refrigeration and air conditioning systems.

Chlorofluorocarbons (CFCs) eg CFC 11 and CFC 12 are stable, of low toxicity and non-flammable providing low hazard working conditions used in refrigeration and air conditioning systems. When released they permeate into the stratosphere and attack the ozone layer which protects the environment from damaging effects of ultraviolet rays. The Montreal Protocol, an International environmental agreement signed by over 160 countries, mandates the phase-out of CFCs according to an agreed timetable. This now includes hydrochlorofluorocarbons (HCFCs) which also have an adverse effect on the ozone layer.

HCFC 22 is a chemical fluid and by far the largest HCFC refrigerant used globally in refrigeration and air conditioning equipment. HCFC 22 has an Ozone Depletion Potential (ODP) of approximately 5% of CFC 11. After CFCs have been phased out, the chlorine content of HCFC 22 will make it the largest ozone depleting substance in volumetric terms. HCFC 22 is also the subject of a phase-out schedule under the Montreal Protocol. HCFC 22 is prohibited from use in new equipment in some countries.

Any replacement for HCFC 22 must have no ability to deplete ozone. The compositions of the present invention do not include chlorine atoms and consequently they will have no deleterious effect on the ozone layer while providing a similar performance as a working fluid to HCFC 22 in refrigeration apparatus.

Various terms have been used in patent literature to describe refrigerant mixtures. These may be defined as follows:

Zeotrope: A fluid mixture whose vapour and liquid compositions are different at a specified temperature.

Temperature glide: If a zeotropic liquid is distilled at constant pressure its boiling point will increase. The change in boiling point from the beginning of the distillation until the point when a liquid phase has just disappeared is called the temperature glide. A glide is also observed when the saturated vapour of a azeotrope is condensed at constant pressure.

Azeotrope: A fluid mixture of specified composition whose vapour and liquid compositions are the same at a specified temperature. Strictly speaking a flid mixture which is an azeotrop under for example evaporator conditions, cannot also be an azeotropes under the condenser conditions. However the refrigeration literature may describe a mixture as azeotropic provided that it meets the above definition at some temperature within its working range.

Near-azeotropes: A blend which boils over a small temperature range, that has a small temperature glide.

Retrofit refrigerant mixture: A non-chlorine-containing mixture used to replace completely the original CFC or HCFC refrigerant.

Extender refrigerant mixture: A non-chlorine-containing mixture added during servicing to the CFC or HCFC refrigerant remaining in a unit, that is a top up refrigerant to make good any leakage.

Hermetic compressor: A compressor where the electric motor is in the same totally welded casing as the compressor. The motor is cooled by the refrigerant vapour returning to the compressor. The heat generated by the motor is removed through the condenser.

Semi-hermetic compressor: Similar to a hermetic compressor, the major difference being the casing has a bolted joint which can be opened to enable the motor and compressor to be serviced.

Open compressor: A compressor which is driven by an external motor via a drive shaft passing through the compressor casing. The motor heat is dissipated directly to the environment, not via the condenser. This results in a slightly more efficient performance than a hermetic compressor, but refrigerant leaks can occur at the shaft seal.

Percentages and proportions referred to in this specification are by weight unless indicated otherwise. Percentages and proportions are selected to total 100%.

According to a first aspect of the present invention a refrigerant composition comprises 1,1,1,2-tetrafluoroethane (HFC 134a), pentafluoro ethane (HCFC 125) and optionally an additive selected from a saturated hydrocarbon or mixture thereof boiling in the range –5 to +70°C; wherein the ratio of weights of HCFC 125 to HCFC 134a is in the range 50 to 78:100.

These compositions may be used as retrofit refrigerant mixtures. The composition may also be used as extenders as discussed below. The compositions may be used in semi-hermetic and hermetic systems.

The preferred ratio of HCFC 125 to HCFC 134a is 60 to 78:100, preferably 60 to 78:100, more preferably 64 to 76:100 in a hermetic and semi-hermetic system. The composition may also be used in an open system. The preferred ratio in an open system is 57 to 78:100 more preferably 63 to 76:100. The proportion of HCFC 125 used in an open system may be up to 10%, preferably about 4-5% higher than in a hermetic or semi-hermetic system.

The hydrocarbon additive preferably has a boiling point in the range 20 to 40°C. Preferred hydrocarbons additives are selected from the group consisting of: 2-methylpropane, 2,2-dimethylpropane, butane, pentane, 2-methylbutane, cyclopentane, hexane, 2-methylpentane, 3-methylpentane, 2,2-dimethybutane and methylcyclopentane. Use of n-pentane is preferred.

The amount of hydrocarbon additive may be up to 10%, preferably 1 to 8 % and more preferably about 4%.

According to a second aspect of the present invention a refrigerant extender mixture comprises a composition in accordance with the first aspect of this invention.

According to a third aspect of this invention a refrigerant composition comprises a composition in accordance with the first aspect of this invention together with HCFC 22. This invention also provides a method of modifying a refrigerator or air conditioning system incorporating HCFC 22 as refrigerant, the method comprising the step of adding a composition in accordance with the second aspect of this invention to the refrigerant of the system.

Positive displacement compressors, that is reciprocating or rotary compressors, used in refrigeration systems suck in small amounts of lubricant from the crank case which are ejected with the refrigerant vapour through the exhaust valves. In order to maintain compressor lubrication this oil must be forced around the circuit by the refrigerant stream and returned to the crank case. CFC and HCFC refrigerants are miscible with hydrocarbon oils and hence carry the oils around the circuit. However HFC refrigerants and hydrocarbon lubricants have low mutual solubilities so effective oil return may not occur. The problem is particularly acute in evaporators where low temperatures can increase the viscosities of oils sufficiently to prevent them being carried along the tube walls. With CFCs and HCFCs enough refrigerant remains in the oil to reduce the viscosities to enable oil return to occur.

When using HFCs with hydrocarbon lubricants oil return can be facilitated by introducing into the system a hydrocarbon fluid having the following properties:

(a) sufficient solubility in the lubricant at the evaporator temperature to reduce its viscosity; and

(b) sufficient volatility to allow distillation from the hot lubricant in the compressor crank case.

Hydrocarbons fulfil these requirements.

Refrigerant compositions in accordance with this invention confer several advantages. The presence of HFC 125 suppressess the flammability of the refrigerant mixture. HFC 125 has fire suppressing characteristics. The higher HFC content enables more n-pentane to be added to the mixture thereby reducing the solubility of the mixture in traditional lubricants, for example mineral and alkyl benzine oils.

The present invention may confer a number of benefits in comparison to HCFC 22 including lower vapour pressure, greater oil miscibility, lower discharge temperature, lower discharge pressure, higher non-flammability, lower combustibility, improved cooling of the motor in a refrigeration apparatus and lower Delta P across the compressor. The boiling point of HCFC 125 is higher than either HCFC 32 or a combination of HCFC

125 and HFC 32. This means that the refrigerant of this invention has a lower glide than some replacements for HCFC 22 which contain HCFC 32.

The invention is further described by means of examples but not in any limitative sense.

EXAMPLE 1

The performances of five R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as retrofit replacements for R22 in hermetic or semi-hermetic systems. The operating conditions, used for the analyses were chosen as being typical of those conditions that are found in air conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following refrigerant compositions were subjected to cycle analysis:

1. A composition comprising 44% R125 by weight, 56% by weight R134a
2. A composition comprising 56% R125 by weight, 44% by weight R134a
3. A composition comprising 64% R125 by weight, 36% by weight R134a
4. A composition comprising 76% R125 by weight, 24% by weight R134a
5. A composition comprising 80% R125 by weight, 20% by weight R134a

The following cycle conditions were used in the analysis:

COOLING DUTY DELIVERED	10 kW

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficienct	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 1. For comparison the performance of R22 is also shown.

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account. However composition 5 is unacceptable because it exhaust pressure is more than 2 bar above that of R22. Composition 1 is unacceptable because the refrigerant capacity is less than 90% of that of R22. The overall performances of

compositions 2, 3 and 4 meet the criteria set out above and therefore satisfy the requirements of this invention.

EXAMPLE 2

The performances of five R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as retrofit replacements for R22 in open systems. The operating conditions, used for the analyses were chosen as being typical of those conditions that are found in air-conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following refrigerant compositions were subjected to cycle analysis:

1. A composition comprising 44% R125 by weight, 56% by weight R134a
2. A composition comprising 56% R125 by weight, 44% by weight R134a
3. A composition comprising 64% R125 by weight, 36% by weight R134a
4. A composition comprising 76% R125 by weight, 24% by weight R134a
5. A composition comprising 80% R125 by weight, 20% by weight R134a

The following cycle conditions were used in the analysis:

COOLING DUTY	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C

Suction line pressure drop (in saturated temperature)	1.5 °C

CONDENSER

Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C

LIQUID LINE/SUCTION LINE HEAT EXCHANGER

Efficiency	0.3

COMPRESSOR

Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

PARASITIC POWER

Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 2. For comparison the performance of R22 is also shown.

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account. However composition 5 is unacceptable because its exhaust pressure is more than 2 bar above that of R22. Compositions 1 and 2 are unacceptable because their refrigerant capacities are less than 90% of that of R22. The overall performances of compositions 3 and 4 meet the criteria set out above and therefore satisfy the requirements of this invention.

EXAMPLE 3

The performances of five R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as retrofit replacements for R22 in hermetic or semi-hermetic systems not fitted with a liquid line/suction line heat exchanger. The operating conditions, used for the analyses were chosen as being typical of those conditions that are found in air conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following refrigerant compositions were subjected to cycle analysis:

1. A composition comprising 44% R125 by weight, 56% by weight R134a
2. A composition comprising 56% R125 by weight, 44% by weight R134a
3. A composition comprising 64% R125 by weight, 36% by weight R134a
4. A composition comprising 76% R125 by weight, 24% by weight R134a
5. A composition comprising 80% R125 by weight, 20% by weight R134a

The following cycle conditions were used in the analysis:

COOLING DUTY	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperate	1.5 °C

CONDENSER

Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C

COMPRESSOR

Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

PARASITIC POWER

Indoor fan	0.47 kW
Outdoor fan	0.26 kW
Controls	0.1 kW

The results from analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 3. For comparison the performance of R22 is also shown.

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account. However composition 5 is unacceptable because its exhaust pressure is more than 2 bar above that of R22. Compositions 1 and 2 are unacceptable because their refrigerant capacities are less than 90% of that of R22. The overall performances of compositions 3 and 4 meet the criteria set out above and therefore satisfy the requirements of this invention.

<u>EXAMPLE 4</u>

The performances of two R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as extenders for R22 in hermetic or semi-hermetic systems. The operating conditions selected for the analyses are typical of those

conditions found in air conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle and were also used to generate the performance of R22 for comparison.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following R22 extender compositions were subjected to cycle analysis:

1. A composition comprising 64% R125 by weight, 36% by weight R134a.
2. A composition comprising 44% R125 by weight, 56% by weight R134a.

To establish the effects on unit performance resulting from successive dilutions of R22 by the above extenders the cycle was analysed for refrigerant compositions containing mass fractions of R22 from 1.0 down to 0.0. The results are summarised in Tables 4a and 4b. Key parameters are plotted in Chart 1 with the calculated points connected by smooth curves.

The following cycle conditions were used in the analysis:

COOLING DUTY	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C

LIQUID LINE

Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

PARASITIC POWER

Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account.

Composition 1 provides a cooling capacity greater than 90% of that of R22 over the whole of the dilution range. Blends containing more than 45% R22 have capacities equal to or better than that of R22. The COP (system) is within 2% of that of R22 over the whole of the dilution range. This composition therefore meets the requirements of this invention.

Composition 2 provides a cooling capacity greater than that 90% of R22 for blends containing down to 20% of R22. Its COP (system) is essentially the same as that of R22 over the whole of the dilution range. This composition therefore meets the requirements of this invention for blends containing down to 20% R22.

EXAMPLE 5

An R32/R134a/pentane composition was evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess its suitability as an extender for R22 in hermetic or semi-hermetic systems. The operating conditions selected for the analysis are typical of those conditions found in air conditioning systems. Since the blend was a zeotrope the midpoints of its temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R32/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following R22 extender composition was subjected to cycle analysis: A composition comprising 44% R125 by weight, 56% by weight R134a.

To establish the effect on unit performance resulting from successive dilutions of R22 by topping up with the above extender the cycle was analysed for refrigerant compositions containing mass fractions of R22 from 1.0 down to 0.0. The results are shown in Table 5 and the results plotted out in Chart 2 with the calculated points connected by smooth curves.

The following cycle conditions were used in the analysis:

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

PARASITIC POWER

Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

All blends containing the extender have lower exhaust temperatures than R22 and therefore meet the requirements of this specification. The COP (system) is essentially equal to that of R22 over the whole of the dilution range. The cooling capacity of the refrigerant is not less than 98% of that of R22 over the whole of the dilution range. For dilutions down to 20% of R22 the capacity is equal to or greater than that of R22. The exhaust pressure is less than the 0.5 bar above that of R22 over the whole of the dilution range.

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 5.

R32/R134a 30/70 therefore meets the requirements of this invention.

EXAMPLE 6

An R32/R125/R134a/pentane composition was evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess its suitability as an extender for R22 in hermetic or semi-hermetic systems. The operating conditions selected for the analysis are typical of those conditions found in air conditioning systems. Since the blend was a zeotrope the midpoints of its temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R32/R134a blend.

This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following R22 extender composition was subjected to cycle analysis:

A composition comprising 23% by weight of 32, 25%R125 by weight and 52% by weight R134a.

To establish the effect on unit performance resulting from successive dilutions of R22 by topping up with the above extender the cycle was analysed for refrigerant compositions containing mass fractions of R22 from 1.0 down to 0.0. The results are shown in Table 6 and the results plotted out in Chart 3 with the calculated points connected by smooth curves.

The following cycle conditions were used in the analysis:

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.8
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 6.

All blends containing the extender have lower exhaust temperatures than R22 and therefore meet the requirements of this specification. The COP (system) is not less than 98% of that of R22 over the whole of the dilution range. The cooling capacity of the refrigerant is greater than of that of R22 over the whole of the dilution range. The exhaust pressure is less than the 2.0 bar above that of R22 over the whole of the dilution range.

R32/R134a in the ratio 30/70 therefore meets the requirements of this invention.

EXAMPLE 7

R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess their suitabilities as retrofits for R12 in hermetic or semi-hermetic systems. The operating conditions selected for the analysis are typical of those conditions found in refrigeration systems. Since the blends were, strictly speaking, zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R12.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

Compositions containing 1 and 15% R125 were considered.

The following cycle conditions were used in the analysis:

EVAPORATOR

Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C

CONDENSER

Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C

LIQUID LINE/SUCTION LINE HEAT EXCHANGER

Efficiency	0.3

COMPRESSOR

Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

PARASITIC POWER

Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Control	0.1 kW

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 7 and key parameters plotted in Chart 4.

All blends have lower exhaust temperatures than R12 and therefore meet the requirements of this specification on this account.

The COPs (system) are not less than 97% of that of R12. The cooling capacities of all the compositions are greater than 90% of that of R12 over the whole of the dilution range.

Compositions containing 3% or more R125 have capacities greater than 95% of that of R12. Compositions containing 12 % or more of R125 have capacities greater than that of R12.

The discharge pressures do not exceed that of R12 by more than 2 bar for all compositions.

All compositions meet the requirements of this invention. Compositions with 9 to 13 % R125 are especially promising, providing a good compromise between discharge pressure and capacity.

EXAMPLE 8

R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess their suitabilities as retrofits for R12 in mobile air conditioning systems systems. The operating conditions selected for the analysis are typical of those conditions found in MAC systems. Since the blends were, strictly speaking, zeotropes the midpoints of its temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R12.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

Compositions containing 1 and 17% R125 were considered.

The following cycle conditions were used in the analysis:

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	60.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7

Compressor volumetric efficiency	0.82
PARASITIC POWER	
Condenser fan	0.4 kW

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 7 and key parameters plotted in Chart 5.

All blends have lower exhaust temperatures than R12 and therefore meet the requirements of this specification on this account.

The cooling capacities of all the compositions are greater than of that of R12 over the whole of the range.

Compositions containing up to 3% of R125 have discharge pressures that do not exceed that of R12 by more than 2 bar.

For high capacities in equipment that can withstand higher pressures 5 to 17% R125 is preferred and especially preferred is 10 to 17%.

If maximum pressure is a concern then blends containing 0 to 3 % 125 are preferred which boost capacity but do not exceed the pressure of R12 by more than 2 bar. These blends are near-azeotropic.

EXAMPLE 9

R12/R-134a/pentane compositions were evaluated in a typical refrigeration system to assess (a) the minimum amount of pentane required in R-134a to provide proper oil return using mineral oil in the typical refrigeration system operating in medium or high temperature applications; and (b) if the resulting mixture provides co-efficients of performance and pressures and temperatures similar to a system operating on R-12.

The refrigeration system used comprised a 0.37 kW type Danfoss model DA05H1AAN air-cooled hermetic compressor with a design evaporation temperature of -6°C to +10°C and a capacity of 967 W to 1861 W/hr. The unit was fitted with a tube in tube evaporator and an oil sight glass was fitted to the compressor. The system was charged with 3 G oil (150 viscosity) and was operated as a condensing system to condense R22 vapour from the top of a heated cylinder. The condensate flow was by gravity from

the evaporator/condenser to a second unheated cylinder. The system capacity was determined by the weight of R22 condensed during a fixed time period. The flow of R22 vapour to the evaporator/condenser was restricted manually to provide various load conditions. All pressure, temperature capacity and amperage readings were taken hourly and averaged over a six to eight hour period. A connection on the discharge line and evaporator inlet facilitated vapour sampling and allowed addition of graduated amounts of pentane to the system.

The system was charged with 3 Gs oil (150 viscosity). The system was operated as a condensing system to condense R-22 vapours from the top of a heated cylinder and the condensate flowed by gravity from the evaporator/condenser to a second unheated cylinder. The system capacity was determined by the weight of R-22 condensed during a fixed time period. The flow of R-22 vapour to the evaporator/condenser was restricted manually to provide various load conditions.

In stage 1 of the trial, the system was initially operated with a charge of 1.2 kg of R-12. The following data was monitored and recorded - voltage, amperage, suction pressure, suction temperature, discharge pressure, discharge temperature, liquid line temperature, evaporator temperature, ambient temperature, oil level, source and receiving cylinder temperatures and process rates in kg/m. The data was measured hourly and averaged over an 18 hour period. During this time the evaporator temperatures were controlled by restricting the inlet of purge gas and were monitored over a range of temperatures between -34°C and -6°C.

In stage 2 of the trial, all R-12 was removed from the system leaving the oil in place. This was then replaced with R-134a at approximately 90% of original R-12 charge by weight. The oil level was again recorded. The refrigeration system was then operated for several days and the above data recorded at hourly intervals.

It was noted that after many days of operation at various load conditions the oil level in the compressor did not change.

15m of suction line was then added to the system, again with no change in oil level. Oil return was then inhibited and after several days of operation the oil level dropped by approx 10mm.

Pentane was added to the R-134a to a maximum of 2% of the original charge by weight. After approx 18 hours the oil level increased by approx 6mm.

Additional amounts of pentane were later added up to a maximum of 6% of original refrigerant charge with smaller increases in oil level observed with each addition of pentane.

Referring to Table 8 the following observations can be made in respect of stage 2 of the trial (as compared to stage 1).

(a) oil return was improved with the addition of pentane;

(b) capacities were slightly higher under all load conditions;

(c) energy consumption was slightly lower under all load conditions;

(d) discharge pressures were slightly higher on average;

(e) suction pressures were similar on average;

(f) discharge temperatures were slightly higher on average;

(g) suction temperatures were considerably higher on average; and

(h) there was no apparent negative impact on the system operation or components.

It was noted that the mixture became flammable in concentrations of 10% or more of pentane based on an open flame test and percentages as determined by gas chromatography area percentage.

Fractionation of the mixture was evident with percentages varying from 1% to 20% of pentane or a mixture of 6% by weight.

It was believed that the pentane may have been concentrated in the compressor crank case oil during the off cycle.

It may be concluded that a mixture of R-134a plus 2% pentane installed as a drop in replacement provided oil return and equal or better capacity and higher efficiency for a medium or high temperature R-12 commercial system with no immediate negative effects on the equipment or operation. Blends with more than 2% pentane could fractionate to the point of flammability under certain conditions. Systems with large refrigerant oil charges and relatively small compressor crank case oil charges could be susceptible to compressor

damage if pentane content in the oil reached concentrations that would affect the lubricity of the oil or cause foaming of the oil on start up after extended shut down periods.

EXAMPLE 10

R-12/R134a/pentane mixtures were evaluated using an automotive air conditioning system to determine if the mixture best suited for commercial refrigeration systems as referred to in the previous example could also be used as a drop in replacement for R-12 in automotive air conditioning systems.

The air conditioning system was that of a 1990 Chrysler mini van having a 3.3 litre engine. The existing charge of R-12 in the air conditioning system was recovered and the system evacuated to 300 μm pressure. This was then recharged with 0.82 kg of R-12 as recommended by the vehicle manufacturer. Finally, temperature sensors were installed on the suction line, discharge line, evaporator air outlet and condition space of the system.

In stage 1 of the trial suction pressure, discharge pressure, suction temperature, discharge temperature, evaporator leaving air temperature, condition space temperature, ambient temperature and engine rpm were measured for the system at idle conditions and again at 2000 rpm. All data was recorded with the vehicle stationary.

In stage 2 of the trial the R-12 trial was recovered and the system again evacuated to 300 μm pressure. The system was then charged with R-134a and a 2% pentane mixture at volume equal to 90% of the original recommended charge. The same data was recorded as for stage 1 of the trial.

Finally, in stage 3 of the trial the R-134a/pentane mixture was recovered and the system again evacuated to 300 μm pressure. The system was then charged with R-134a (88%)/R-125 (10%)/pentane (2%). The same data was again recorded.

With reference to Table 9 it was seen that in stage 2 (when compared to stage 1)

(a) discharge pressures were on average 8% higher at idle and 4% higher at 2000 rpm;

(b) discharge temperatures were on average 3% lower at idle and 12% lower at 2000 rpm:

(c) other temperature and pressure readings showed no significant change;

(d) there was no apparent loss of capacity in this system; and

(e) there was no apparent negative impact on the system operation or components.

With reference to Table 10 it was seen that in stage 3

(a) there was no significant change to the temperatures and pressures when the 10% R-125 was added to the blend; and

(b) there was no apparent negative impact on the system operation or components.

EXAMPLE 11

R-12/R135a/pentane/R125 mixtures were evaluated using the air conditioning system of a 2 litre 1987 Toyota Camrie.

As in Example 12, the existing charge of R-12 was evacuated from the air conditioning system and the pressure of this system reduced to 300 μm. This was then recharged with 0.68 kg of R-12 as recommended by the vehicle manufacturer. The air conditioning system was fitted with temperature sensors on the suction line, discharge line, evaporator air outlet and conditioned space.

In stage 1 of the trial data including suction pressure, discharge pressure, suction temperature, discharge temperature, evaporator leaving air temperature, conditioned space temperature, ambient temperature and engine rpm were measured at idle conditions and again at 2000 rpm. All data was recorded with the vehicle stationary.

In stage 2 of the trial the R-12 was recovered from the system and again evacuated to 300 μm air pressure. The systems was then charged with a mixture of R-134a (88%)/R-125 (10%)/pentane (2%) equal to 90% of the original charge. The same data as in stage 1 was then recorded.

With reference to Table 11 it was seen that in stage 2 (compared to stage 1)

(a) discharge pressures were on average 18% higher at idle conditions and 6% higher at 2000 rpm; and

(b) there was no apparent negative impact on the system operation or components.

It was concluded from Examples 10 and 11 that a mixture of R-134a plus 2% pentane installed as a drop in replacement for R-12 in automotive air conditioning systems appears to provide similar capacity and no immediate negative effect on the equipment or operation. The addition of 10% R-125 to the above mixture does not have any significant effect on the previous pressures and temperatures of the system.

EXAMPLE 12

R-12/R-134a/pentane/R-125 compositions were evaluated using domestic refrigerator and freezer systems.

In a first trial a domestic refrigeration system was used. The system's specifications are as follows -

Manufacturer : General Electric
Size : 198 cubic litres
Kw : .1 kw
Type : single door, single evaporator with freezer compartment, non-frost-free
Age : approx 25 to 30 years
Refrigerant charge : 0.128 kg
Voltage : 115/1/60

Gauges were installed on the suction and discharge lines. Temperature sensors were attached to suction and discharge lines approx 15 cm from the compressor.

In a first stage the system was operated with the existing R-12 refrigerant charge. The following data were recorded - voltage, amperage, suction pressure, suction

temperature, discharge pressure, discharge temperature, space temperature, ambient temperature and compressor run time.

In the second stage the R-12 charge was recovered and the system was evacuated to 300 μm pressure. The system was then recharged with R-134a/pentane (98/2%) mixture with approx 90% by weight of the original charge. The system was again operated and the same data as before recorded.

Finally, in stage 3 the R-134a/pentane mixture was recovered and the system was recharged with R-134a/R-125/pentane (88/10/2%) mixture with the same amount by weight as stage 2. The system was again operated and the same data as above recorded.

The results of these three stages are recorded in Table 12.

In a second trial a domestic freezer was used. The specification of the system are as follows:

Manufacturer : Viking

Size : 482 cubic litres

Kw : .2 Kw

Type : Chest type, non-frost-free

Age : Approx 25 to 30 years

Refrigerant charge : 0.434 kg

Voltage : 115/1/60

Gauges were installed on the suction and discharge lines. Temperature sensors were installed on suction and discharge lines approx 15 cm from the compressor.

In a first stage the system was operated with the existing R-12 refrigerant charge and the following data recorded - voltage, amperage, suction pressure, suction temperature, discharge pressure, discharge temperature, space temperature, ambient temperature and compressor run time.

In a second stage the R-12 charge was recovered and the system evacuated to 300 μm pressure. The system was then recharged with R-134a/pentane (98/2%) mixture with approx 90% by weight of the original charge. The system was again operated and the same data as before recorded

Finally, in stage 3 the R-134a/pentane mixture was recovered and replaced with R-134a/R125/pentane (88/10/2%) mixture with the same amount by weight of stage 2. The system was again operated and the same data recorded.

The data from all three stages is reproduced as Table 13.

With reference to Table 13 it was seen there are no significant changes in operating pressures, temperatures or efficiencies on changing the mixture. There was no apparent negative impact on the system operation or components.

In conclusion, a mixture of R-134a plus 2% pentane installed as a drop in replacement for R-12 domestic refrigerators and freezers appears to provide a similar capacity and no immediate negative effects on the equipment or operation. The addition of 10% R-125 to the above mixture did not have any significant effect on the previous pressures and temperatures or operation of the systems.

Table 1

Refrigerant % by weight	R-22	1. 125/134a 44/56	2. 125/134a 56/44	3. 125/134a 64/36	4. 125/134a 76/24	5. 125/134a 80/20
Discharge pressure (bar)	17.91	15.89	17.19	18.13	19.68	20.23
Discharge temperature (°C)	104.68	79.75	78.51	77.60	76.07	75.51
COP (system)	2.49	2.50	2.47	2.45	2.41	2.40
Capacity (kW/m^3)	3066	2581	2747	2862	3041	3102
Glide in evaporator (°C)	0	3.06	3.17	3.03	2.47	2.19
Glide in condenser (°C)	0	2.97	2.94	2.71	2.09	1.81

Table 2

Refrigerant % by weight	R-22	1. 125/134a 44/56	2. 125/134a 56/44	3. 125/134a 64/36	4. 125/134a 76/24	5. 125/134a 80/20
Discharge pressure (bar)	17.91	15.89	17.19	18.13	19.68	20.23
Discharge temperature (°C)	92.9	72.8	71.9	71.2	70.1	69.7
COP (system)	2.59	2.57	2.54	2.52	2.48	2.47
Capacity (kW/m^3)	3222	2669	2838	2956	3138	3200
Glide in evaporator (°C)	0	3.06	3.17	3.03	2.47	2.19
Glide in condenser (°C)	0	2.97	2.94	2.71	2.09	1.81

Table 3

Refrigerant % by weight	R-22	1. 125/134a 44/56	2. 125/134a 56/44	3. 125/134a 64/36	4. 125/134a 76/24	5. 125/134a 80/20
Discharge pressure (bar)	17.91	15.89	17.19	18.13	19.68	20.23
Discharge temperature (°C)	94.63	71.81	70.63	69.71	68.082	67.47
COP (system)	2.45	2.42	2.39	2.37	2.33	2.36
Capacity (kW/m^3)	3077	2535	2692	2800	2965	3021
Glide in evaporator (°C)	0	2.88	2.99	2.87	2.34	2.07
Glide in condenser (°C)	0	2.97	2.94	2.71	2.09	1.81

Table 4a R125/R134a 64%/36% as Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	18.13	18.47	18.69	18.81	18.84	18.80	18.70	18.56	18.37	18.15	17.91
Discharge temperature (°C)	77.6	79.7	81.8	84.0	86.4	89.0	91.7	94.6	97.8	101.1	104.7
COP (system)	2.45	2.45	2.46	2.46	2.47	2.47	2.48	2.48	2.49	2.49	2.49
Capacity (kW/m^3)	2862	2937	2996	3042	3074	3096	3107	3108	3101	3087	3069
Glide in evaporator (°C)	3.03	2.91	2.66	2.36	2.04	1.73	1.41	1.08	0.75	0.39	0
Glide in condenser (°C)	2.71	2.55	2.31	2.06	1.80	1.54	1.28	1.09	0.71	0.38	0

Table 4b R125/R134a 44%/56% as Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	15.90	16.41	16.83	17.17	17.44	17.64	17.79	17.88	17.93	17.93	17.91
Discharge temperature (°C)	79.6	81.7	83.7	85.8	88.0	90.3	92.8	95.5	98.3	101.4	104.7
COP (system)	2.50	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49
Capacity (kW/m^3)	2581	2675	2756	2825	2885	2935	2977	3010	3036	3054	3066
Glide in evaporator (°C)	3.06	3.08	2.91	2.62	2.27	1.89	1.50	1.12	0.74	0.37	0
Glide in condenser (°C)	2.97	2.89	2.66	2.36	2.02	1.69	1.34	1.00	0.67	0.34	0

Table 5 R32/134a 30/70 as an Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	18.08	18.18	18.27	18.33	18.36	18.36	18.34	18.28	18.19	18.07	17.91
Discharge temperature (°C)	98.0	98.4	98.9	99.3	99.8	100.4	101.0	101.8	102.6	103.6	104.7
COP (system)	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49
Capacity (kW/m^3)	3030	3049	3066	3080	3091	3098	3101	3100	3094	3083	3066
Glide in evaporator (°C)	5.03	4.59	4.12	3.62	3.11	2.59	2.07	1.55	1.03	0.51	0
Glide in condenser (°C)	5.13	4.62	4.11	3.60	3.08	2.57	2.07	1.56	1.06	0.54	0

Table 6 R32/125/134a 23/25/52 as an Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	19.30	19.32	19.30	19.25	19.16	19.03	18.87	18.68	18.45	18.20	17.91
Discharge temperature (°C)	92.5	93.3	94.1	95.0	96.0	97.1	98.4	99.7	101.2	102.9	104.7
COP (system)	2.47	2.47	2.47	2.47	2.47	2.48	2.48	2.48	2.49	2.49	2.49
Capacity (kW/m^3)	3172	3183	3190	3193	3191	3183	3171	3157	3129	3101	3066
Glide in evaporator (°C)	4.8	4.4	3.9	3.4	2.9	2.4	1.9	1.5	1.0	0.5	0
Glide in condenser (°C)	4.7	4.2	3.8	3.3	2.8	2.4	1.9	1.5	1.0	0.5	0

Table 7 R125/134a as an R12 Retrofit

Refrigerant % R125 by weight	R12	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Discharge pressure (bar)	11.21	12.05	12.13	12.20	12.28	12.36	12.44	12.51	12.59	12.67	12.75	12.83	12.91	12.99	13.07	13.15	13.24
Discharge temperature (°C)	127.6	118.2	118.0	117.9	117.7	117.5	117.4	117.2	117.1	116.9	116.8	116.6	116.4	116.2	116.1	115.9	115.8
COP (system)	1.36	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Capacity (kW/m³)	698.2	652.7	656.5	660.3	664.2	668.0	671.9	675.9	679.8	683.8	687.8	691.9	695.9	700.0	704.1	708.3	712.4
Glide in evaporator (°C)	0	0	0.08	0.18	0.26	0.35	0.44	0.52	0.61	0.69	0.77	0.85	0.93	1.01	1.09	1.17	1.25
Glide in condenser (°C)	0	0	0.12	0.24	0.35	0.47	0.58	0.69	0.80	0.90	1.00	1.10	1.20	1.30	1.39	1.48	1.56

Table 8 R125/134a as an MAC R12 Retrofit

Refrigerant % R125 by weight	R12	0	1	3	5	7	9	11	13	15	17
Discharge pressure (bar)	15.72	17.42	1752	17.72	17.93	18.14	18.36	18.57	18.79	19.01	19.24
Discharge temperature (°C)	88.4	84.4	84.4	84.3	84.3	84.3	84.2	84.2	84.1	84.1	84.0
COP (system)	2.45	2.38	2.37	2.34	2.36	2.36	2.35	2.34	2.34	2.33	2.32
Capacity (kW/m^3)	1754	1771	1779	1794	1809	1824	1840	1856	1871	1887	1902
Glide in evaporator (°C)	0	0	.08	0.22	0.37	0.51	0.65	0.78	0.91	1.00	1.16
Glide in condenser (°C)	0	0	0.10	0.30	0.50	0.68	0.85	1.02	1.17	1.32	1.46

Table 8 - R-12 versus R-134a/Pentane Mixtures Commercial Refrigeration System

	R-12	R-134a+2%	R-134a+4%	R-134a+6%
HIGH LOAD CONDITIONS				
Suction Pressure	1.72	1.59	1.79	1.59
Suction Temp	6	14	13	16
Discharge Pressure	8.4	8.7	8.4	9
Discharge Temp	59	59	60	63
Capacity	0.3	0.32	0.3	0.29
Ambient Temp	24	21	21	26
Amperage	9.96	9.58	10.5	10.8
MEDIUM LOAD CONDITIONS				
Suction Pressure	0.69	0.83	0.69	0.83
Suction Temp	0	14	13	17
Discharge Pressure	7.5	7.8	7.5	7.8
Dishcarge Temp	56	57	58	59
Capacity	0.14	0.15	0.14	0.17
Ambient Temp	25	22	24	26
Amperage	9.14	8.78	9.8	10.04
LOW LOAD CONDITIONS				
Suction Pressure	-0.1	0	0.1	0
Suction Temperature	.17	16	19	20
Discharge Pressure	5.8	6	7	6.4
Discharge Temp	42	46	47	49
Capacity	0.05	0.05	0.05	0.04
Ambient Temp	21	21	26	25
Amperage	8.7	8.14	9.43	9.25

Pressures are in Bars

Temperatures are in Celsius

Capacity is in Kgs/min

Table 9 - R-12 versus R-134a+2% Pentane

Automotive A/C Application

Vehicle #1 1990 Chrysler Mini-Van

	R-12		R-134a + 2% Pentane	
	1000 rpm	2000 rpm	1000 rpm	2000 rpm
Suction Press	1.72	1.52	2.21	1.52
Suction Temp	17	14	21	12
Discharge Press	12.8	14.1	13.8	14.7
Discharge Temp	74	89	72	78
Supply Air Temp	4	3	5	3
Space Temp	18	16	18	16
Ambient Temp	27	27	25	25

Pressures are in Bars

Temperatures are in Celsius

Vehicle Stationary

Table 10 - R-134a + Pentane versus R-134a + R125 + Pentane

Automotive A/C Application

Vehicle #1 1990 Chrysler Mini-Van

	R-134a + 2% Pentane		R-134a + R-125 + Pentane	
	1000 rpm	2000 rpm	1000 rpm	2000 rpm
Suction Press	1.38	1.38	1.53	1.5
Suction Temp	8	10	10	12
Discharge Press	13.62	13.03	13.62	13.62
Discharge Temp	71	80	69	74
Supply Air Temp	12	13	12	13
Space Temp	12	13	12	13
Ambient Temp	9	9	10	10

Pressures are in Bars

Temperatures are in Celsius

Vehicle Stationary

Table 11 - R-12 versus R-134a/R-125/Pentane (88/10/2%)

Automotive A/C Application

Vehicle #2 1987 Toyota Camry

	R-12		R-134a/R-125/Pentane	
	1000 rpm	2000 rpm	1000 rpm	2000 rpm
Suction Press	1.33	1.24	1.38	1.19
Suction Temp	-3	-5	0	-3
Discharge Press	8.39	11.03	9.88	11.72
Discharge Temp	47	69	49	78
Supply Air Temp	4	5	5	3
Space Temp	9	7	7	7
Ambient Temp	9	11	10	10

Pressures are in Bars

Temperatures are in Celsius

Vehicle Stationary

Table 12 - R-12 Replacement Test Results

Domestic Refrigerator

	R-12 100%	R-134a/P 98/2%	R-134a/R-125/P 88/10/2%
Suction Press	0.34	0.21	0.21
Suction Temp	22	20	17
Discharge Press	8.5	8.2	8.33
Discharge Temp	63	60	56
Space Temp	3	3	1
Ambient Temp	27	24	22
Amperage	1.49	1.47	1.37
Voltage	118	117	118
Run Time/24 Hours	12.34	10.64	12.98

Pressures are in Bars

Temperatures are in Celsius

Table 13 R-12 Replacement Test Results

Domestic Freezer

	R-12 100%	R-134a/P 98/2%	R-134a/R-125/P 88/10/1
Suction Press	0.17	0 12	0.17
Suction Temp	17	16	12
Discharge Press	9.24	9.1	9.8
Discharge Temp	60	53	57
Space Temp	-17	-19	-15
Ambient Temp	25	22	22
Amperage	3.72	3.37	3.74
Voltage	117	117	118
Run Time/24 Hours	13.92	12.93	13.27

Pressures are in Bars

Temperatures are in Celsius

CLAIMS

1. A refrigerant composition comprising a hydrofluorocarbon component including 1,1,1,2-tetrafluoroethane (HFC 134a), the composition further comprising an additive selected from a saturated hydrocarbon or mixture thereof boiling in the range −5 to +70°C.

2. A refrigerant composition as claimed in claim 1, wherein the hydrofluorocarbon component is selected from the group consisting of HFC 134a, pentafluoroethane (HFC 125), difluoroethane (HFC 32) and mixtures thereof.

3. A refrigerant composition as claimed in claim 2, wherein the HFC component comprises HFC 125 and HFC 134a wherein the ratio of weights of HFC 125 to HFC 134a is in the range of 50 to 78:100.

4. A refrigerant composition as claimed in claim 3, wherein the ratio is 50 to 78:100.

5. A refrigerant composition as claimed in claim 4, wherein the ratio is 60 to 78:100.

6. A refrigerant composition as claimed in claim 2, wherein the HFC component comprises HFC 125 and HFC 134a wherein the ratio of weights of HFC 125 to HFC 134a is in the range 1 to 15:100.

7. A refrigerant composition as claimed in claim 2, wherein the HFC component comprises HFC 32 and HFC 134a wherein the ratio of weights of HFC 32 to HFC 134a is in the ratio of 25 to 35:100.

8. A refrigerant composition as claimed in claim 5, wherein the hydrocarbon additive has a boiling point in the range of 20 to 50°C.

9. A refrigerant composition as claimed in claims 5 or 6, wherein the hydrocarbon additive is selected from the group consisting of 2-methylpropane, 2,2-dimethylpropane, n-butane, n-pentane, 2-methylbutane, cyclopentane, hexane, 2-methylpentane, 3-methylpentane, 2,2-dimethybutane and methylcyclopentane.

10. A refrigerant composition as claimed in claim 5, wherein the hydrocarbon additive is selected from n-pentane, iso-pentane, cyclopentane or mixtures thereof.

11. A refrigerant composition as claimed in any preceding claim, wherein the amount of hydrocarbon additive is trace to 10%.

12. A refrigerant composition as claimed in claim 9, wherein the amount of hydrocarbon additive is 1 to 8%.

13. A refrigerant composition as claimed in claim 10, wherein the amount of hydrocarbon additive is 2 to 4%.

14. A refrigerant extender mixture comprising a refrigerant composition as claimed in any preceding claim.

15. A refrigerant composition as claimed in any of claims 1 to 11 together with a proportion of HCFC 22.

16. A method of modifying a refrigerator or air conditioning system which incorporates HCFC 22 as refrigerant, the method comprising the step of adding a refrigerant extender as claimed in claim 12 to the refrigerant of the system.

17. Use of a refrigerant composition as an extender to HCFC 22, wherein the HFC component comprises HFC 32, HFC 125 and HFC 134a wherein the ratio of weights of HFC 32, HFC 125 and HFC 134a is in the range 18 to 28, 20 to 30 and 42 to 62:100.

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ABSTRACT

REFRIGERANT

A refrig rant composition comprising a hydrofluorocarbon component including 1,1,1,2-tetrafluoroethane (HFC 134a), the composition further comprising an additive selected from a saturated hydrocarbon or mixture thereof boiling in the range –5 to +70°C.

Figure 1: R125/134a 64/36 and 44/56 as R22 Extenders

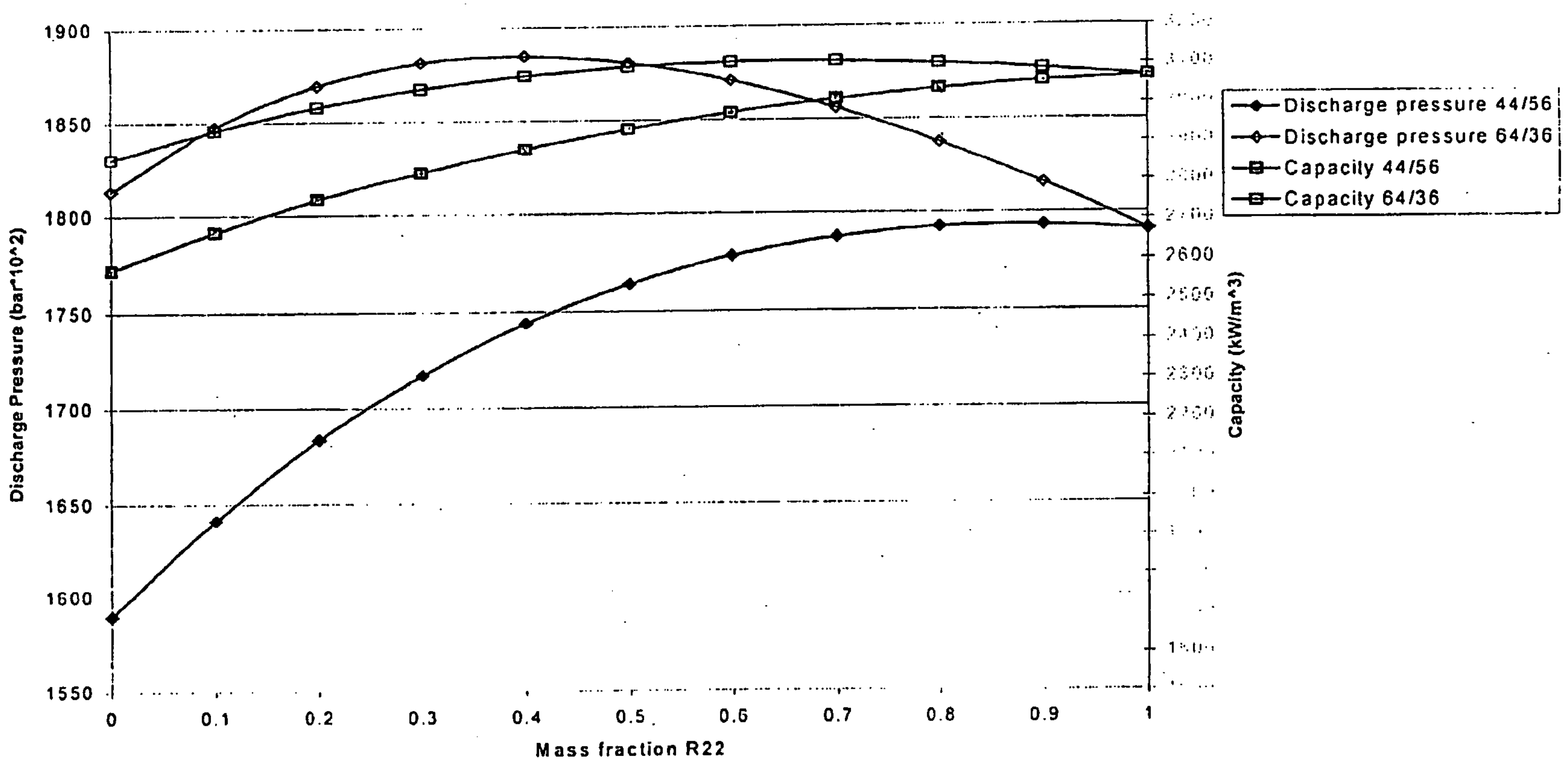

Figure 2: R32(30)/R134a(70) as an extender for R22

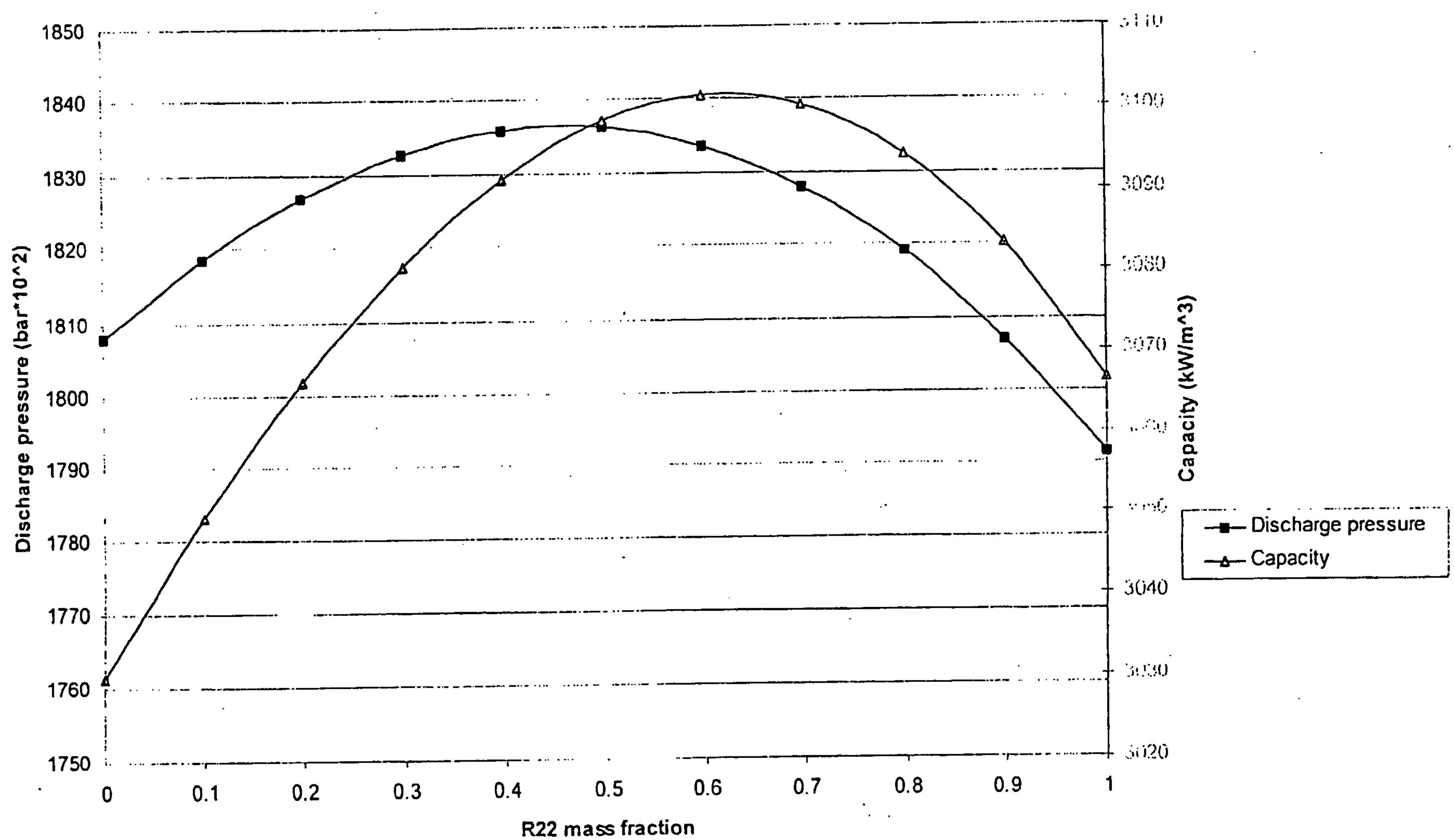

Figure 3: 32/125/134a 23/25/52 as an extender for R22

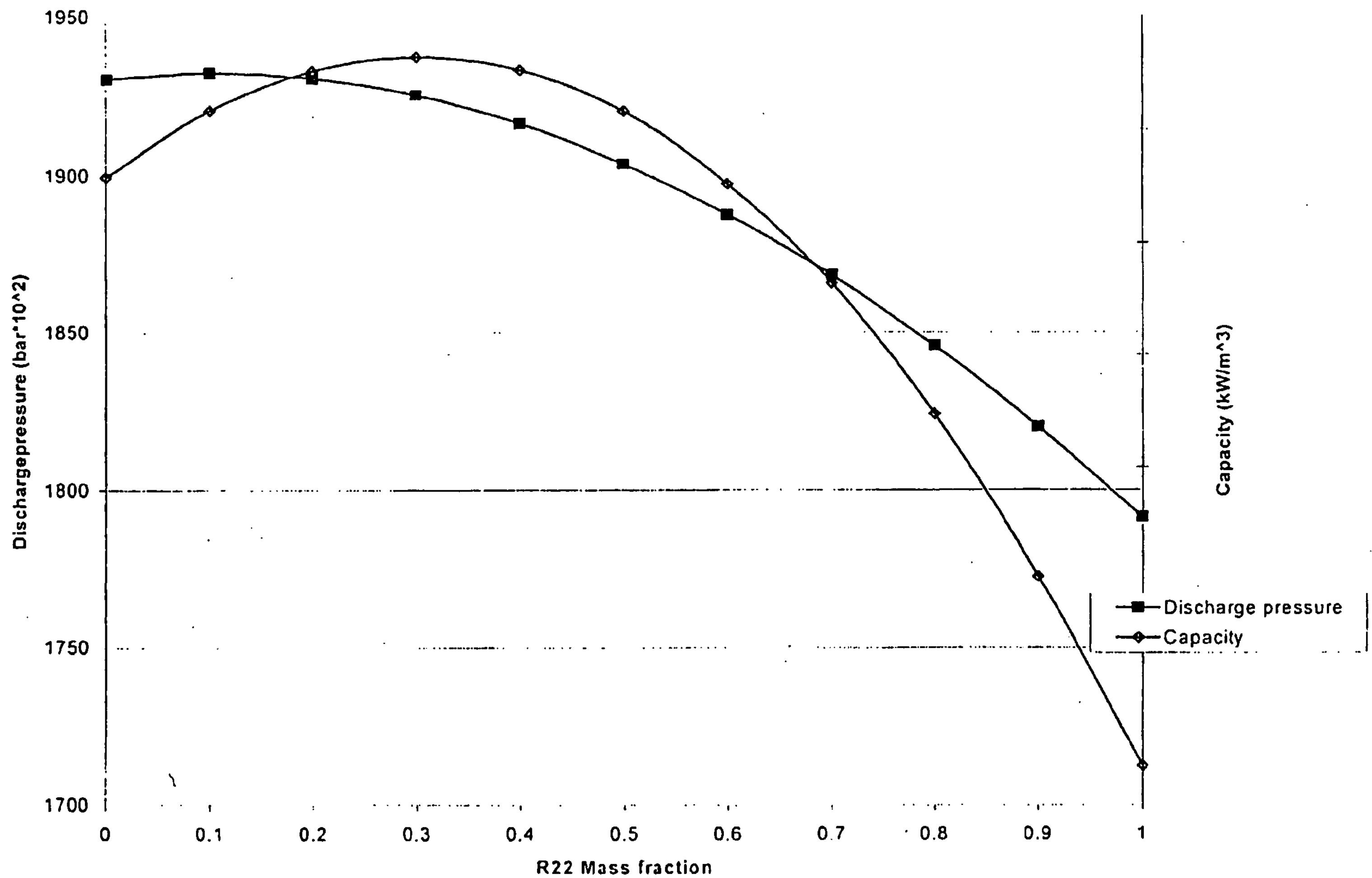

Figure 4: R134a + R125 as an R12 Retrofit

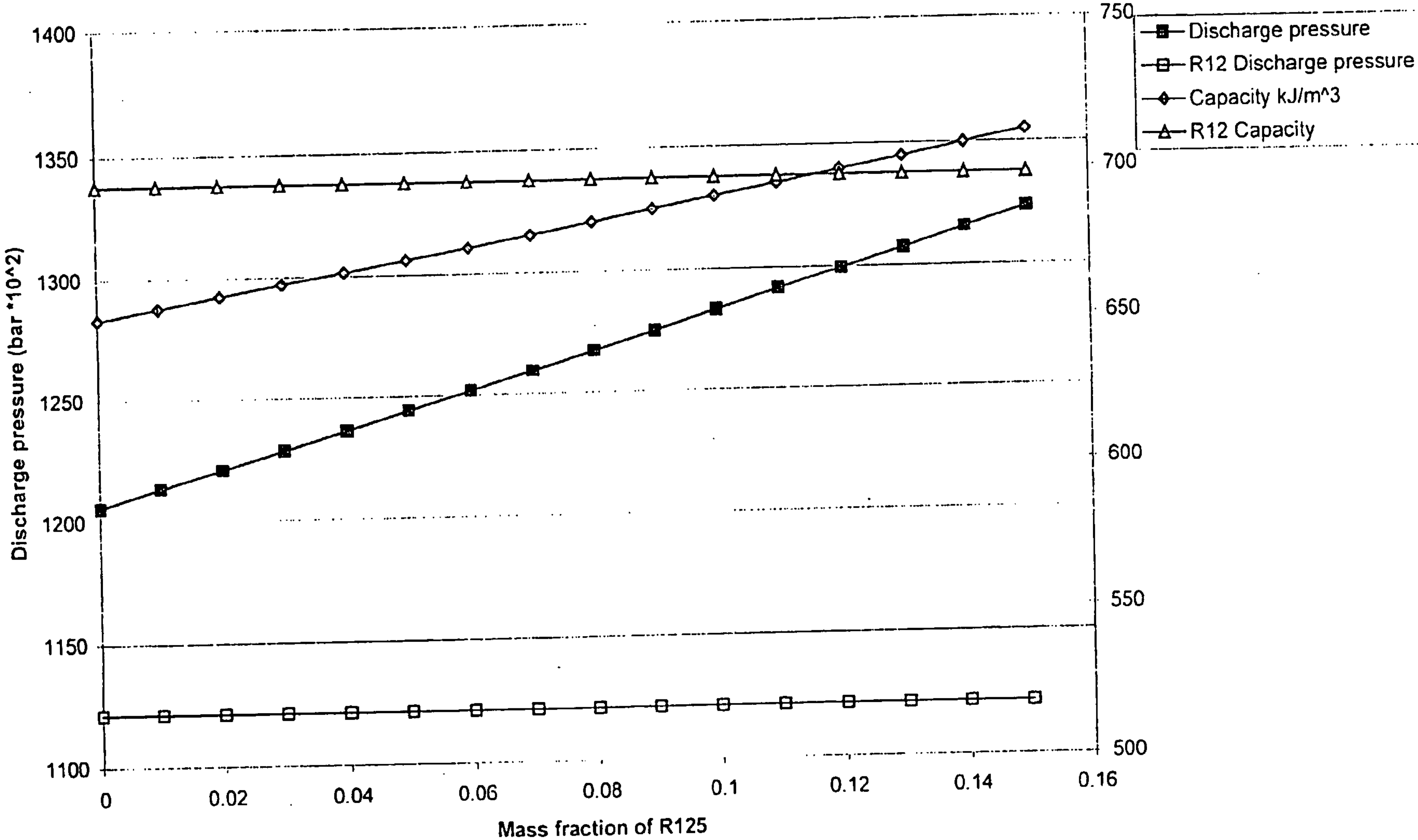

Figure 5: R134a + R125 as an MAC R12 Retrofit